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ABSTRACT: The possibility of differential vulnerability to predation among sex and age segments of a population of *Microtus pennsylvanicus* and between *Microtus* and other small rodents was investigated. Individuals from a small mammal population of a 0.8-ha old-field in southern Michigan were live-trapped, ear-tagged and released during summer and autumn 1972. Fecal matter of domestic cats *(Felis catus)*, which hunted in this field, was collected and analyzed for presence of ear tags. The different species—and sexes and age groups within *Microtus*—eaten by domestic cats were not significantly different from those expected on the basis of relative abundance. A significant seasonal difference, corresponding to actual changes in the age structure of the *Microtus* population, occurred in the proportion of subadult and adult voles taken by domestic cats.

INTRODUCTION

Recent studies on *Microtus* indicate that sociobehavioral attributes may vary considerably among segments of a population. For example, Getz (1972) reported significant sex differences in agonistic behavior in *Microtus pennsylvanicus*. Myers and Krebs (1971) found sex and age differences in the tendency to disperse in both *M. pennsylvanicus* and *M. ochrogaster*. Getz (1961) found sex differences in size and restriction to a home range. The present research attempted to determine whether these or other differences might affect the vulnerability of different sex or age segments of a population of meadow voles *(M. pennsylvanicus)* to predation by a carnivore, the domestic cat *(Felis catus)*, in southern Michigan. Of secondary interest was the comparative vulnerability to predation between *M. pennsylvanicus* and deer mice *(Peromyscus maniculatus)*, jumping mice *(Zapus hudsonius)* and house mice *(Mus musculus)*.

STUDY AREA

This study was carried out in farmland SW of Williamston, Michigan (section 17, T3N, R1E, Ingham Co.). Rodents of a 0.8-ha old-field were live-trapped, marked and released. An adjacent farm, directly across a paved county road from the trapping grid, was occupied by 10-12 domestic cats. Resident cats were fed dry food and table scraps by the owners of the farm, but supplemented their diet by hunting mice, chiefly on the trapping grid. The meadow had been fallow for about 5 years, having last been sown in "Sudex" (DeKalb). Three vegetational areas could be identified on the grid: a central area consisting of bluegrass *(Poa* sp.); a brushy strip along the S and E consisting of burdock (*Arctium* sp.), stinging nettles (*Urtica* sp.) and scrub willows (*Salix* sp.); and an area of brome grass *(Bromus* sp.) and mixed herbaceous plants along the N and W borders. The grid was bordered on the N by a county road, on the W by an alfalfa field, and on the E and S by a small creek.

Several predators in addition to domestic cats were present on the study area. One weasel *(Mustela frenata)* was captured. The presence of domestic dogs and raccoons *(Procyon lotor)* was evidenced by their droppings. A red-tailed hawk *(Buteo jamaicensis)* was observed once in the adjacent alfalfa field, but was not seen on or over the trapping grid.

METHODS

The relative abundances of sex and age segments of *Microtus* and of the other small mammal populations were determined by live-trapping and marking between 19 July and 1 November 1972. One hundred-eighteen live traps (constructed following Fitch, 1950) were placed at 8-m spacings on a permanent grid. Each of the 16 trapping periods were 3 nights long. Traps were baited with rolled oats in late afternoon or early evening, inspected and closed the following morning, and baited and reset that afternoon or evening. The traps were left set during the day when temperatures were low enough to present little danger of excessive heat to animals in traps. The 1st day of each trap period was spaced 1 week from that of the previous period with the following exceptions: trap periods one through three occurred on 9 successive days, and periods four and five were 1 week later on 6 successive days. These trap periods were compressed to allow rapid tagging of as many animals as possible at the beginning of the study. Trap periods nine and ten were spaced 2 weeks apart.

Data recorded from a trapped animal included specific name, location on the grid, sex, weight and, in the case of *Microtus,* reproductive condition. Reproductive condition was assessed following Krebs (1966). Age classes of *Microtus* were established on the basis of body weight. Voles weighing 22 g or less were classified as juveniles, those heavier than 22 but not more than 32 g as subadults, and those weighing more than 32 g as adults.

Individual mice and voles were identified by attaching numbered monel fingerling gill tags (Salt Lake Stamp Co.) on the ear at first capture. Voles were occasionally captured with torn ears, indicating that they had probably lost previously applied tags. This loss, however, was minimal: only 15 individuals were captured in this condition.

The number of voles of each age class and sex eaten by domestic cats was obtained by collecting and analyzing cat droppings for ear tags. Tags were detected by X-ray of scats arranged on sheets of Plexiglas. Scats were found in various locations, but primarily on the trapping grid and in flower beds in the farmhouse yard. Tags were usually recovered in scats soon after the last capture of the vole, so it was necessary to correct for time lag between capture (thus, aging) and time preyed upon.

RESULTS

A total of 5640 trap nights produced 576 captures of 261 *Microtus,* 18 *Peromyscus maniculatus,* 10 *Mus musculus* and one *Zapus hudsonius.* Trap mortality was minimal, only three *Microtus* being found dead in traps.

Microtus *population size and composition.*—Numbers of *Microtus* alive throughout the study were estimated using the direct enumeration technique described by Krebs (1966). All estimates pertain only to the trappable members of the population.

The minimum number of *Microtus* alive during each trap period fluctuated between 15 and 54. The population declined from a total of 110 known to be alive during the 1st 20 days to 59 during the last 16 days of the study. Of the 261 voles captured, 133 were males and 128 females. The age structure of the population during the entire study was 45 juveniles, 90 subadults and 126 adults. Twenty-eight voles (10.7%) were known to have changed age class, and these

have been placed in the class in which they were alive most of the time. Sex ratio of the minimum number known alive was not significantly different from 1:1 during any trap period ($P>.20$). The age structure of the vole population did, however, change considerably during the study. The proportion of three age classes is depicted as a function of time in Figure 1, the total time of the study being divided into four approximately equal periods. Changes in the proportion of the population represented by juveniles were not significant (each $\chi^2<1.45$, $P>.20$). The decrease in the subadult proportion from period 1 to period 2 was not significant ($\chi^2 = 2.58$, $P>.10$), but increases between period 2 and period 3 and between period 3 and period 4 were significant ($\chi^2 = 21.33$, $P<.001$; $\chi^2 = 5.26$, $.02<P<.05$). The adult proportion of the population decreased significantly between the 2nd and 3rd intervals ($\chi^2 = 5.00$, $.02<P<.05$).

Survivorship.—Survivorship for each vole captured was determined from trapping data as the time between first and last capture. Disappearance of a vole could result from dispersal off the grid, death due to predation or other causes, or trap avoidance. Known losses due to predation by domestic cats accounted for approximately 16% of those voles disappearing from the grid. The longest that any vole was known to be alive on the grid was 6.5 weeks. No difference in survivorship was noted between males and females, or between voles of different age at first capture. Mean survivorship did not change significantly during the study.

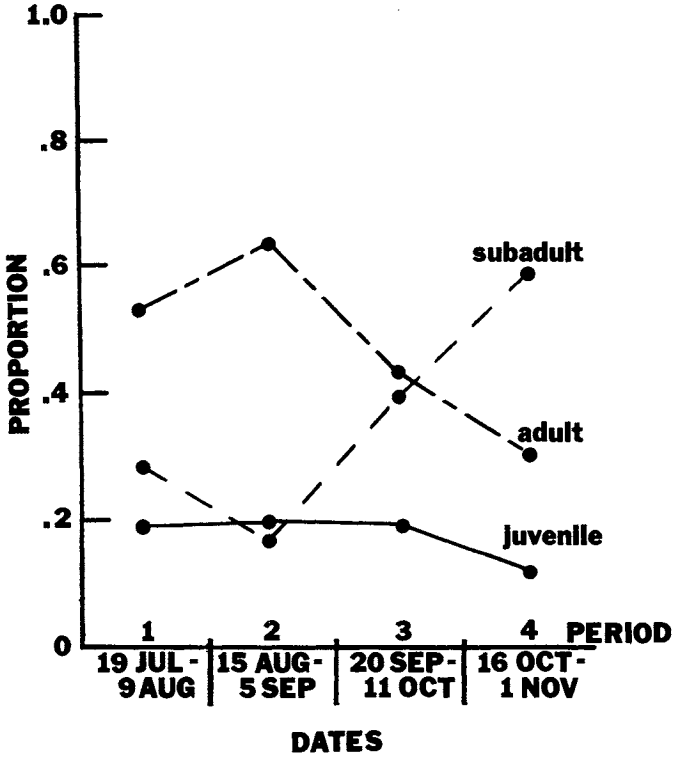

Fig. 1.—Proportion of minimum number of *Microtus* alive in each age segment

Predation.—Forty ear tags, all from *Microtus,* were recovered from approximately 160 scats. The sexes and ages of voles whose tags appeared in scats are shown in Table 1. A chi-square test was used to test the null hypothesis that voles were taken according to their relative abundance in the population (Table 1). Expected values are based on the proportions of sexes and age classes among the 261 voles captured during the study. Meadow voles of different sex and age were preyed upon in proportion to their relative abundance.

Since the relative abundance of adults and subadults changed during the study, the predation suffered by each age class at different times was examined. To accomplish this, the first 20 tags (Group 1) recovered were compared with the second (Group 2). The age structure of the population during the times tagged animals in each group were known to be available to predators (Group 1 —19 July to 22 September; Group 2—25 September to 1 November) was computed to derive expected values on the basis of abundance. Within each of these time periods, each sex and age class was preyed upon in proportion to its abundance (Table 2).

The minimum number of voles alive during the time when Group 1 animals were in the population was 169, while 110 were alive when Group 2 animals were available to predators. Thus, the known percentages of predation were 11% (20/169) for Group 1 animals and 18% (20/110) for Group 2 animals. This represents a significant increase over time in the proportion of animals alive that were known to be caught by predators ($\chi^2 = 5.33$, $.02<P<.05$). It is not known whether this increase was due to an increased number of predators, a deterioration of vegetation or some other cause.

DISCUSSION

The results for vole sex and age segments may be interpreted in at least two ways: (1) all voles are equally vulnerable; or (2) some individuals may be highly vulnerable but these occur in equal proportions in the various segments of the population. In light of the evidence of behavioral differences among voles, the second hypothesis seems more tenable.

An inherent difference among voles in vulnerability may be masked by the

TABLE 1.—Sexes and ages of *Microtus* whose tags were recovered from cat fecal matter. Expected values based on proportion of total capture in each class over the entire study

Class		Percentage of class in population	Expected	Observed	χ^2	df	Significance
Male	Juvenile	5.7	2	4	4.00	2	$.10<P<.20$
	Subadult	15.7	6	4			
	Adult	29.5	12	8			
Female	Juvenile	13.0	5	4	1.99	2	$.30<P<.50$
	Subadult	19.5	8	10			
	Adult	16.5	7	10			
Males		50.0	20	16	1.60	1	$.20<P<.30$
Females		49.0	20	24			
Juveniles		18.7	7	8	0.19	2	$.90<P<.95$
Subadults		35.2	14	14			
Adults		46.0	19	18			

hunting strategy of domestic cats. Nonferal domestic cats are, of course, not subject to the same selection pressures as completely wild predators, and thus may have different effects on small mammal populations. Hornocker (1970) has hypothesized that canids (*e.g.*, wolves, *Canis lupus*), which run their prey down, are apt to take sick, weak or aged animals. By contrast, he has hypothesized that mountain lions *(Felis concolor)*, which either slowly approach to within attacking distance or wait in ambush, are apt to take any animal, regardless of condition, that is in a vulnerable position. Domestic cats often employ a sit-and-wait strategy, and thus may take any animal that approaches within pouncing range. If differences existed among prey animals in experience, activity, range and other attributes, these differences could affect liability to predation by domestic cats. However, unless these differences were distributed unequally among segments of a population, results such as those obtained in this study could be expected.

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TABLE 2.—Sexes and ages of *Microtus* whose tags were recovered from cat fecal matter from 19 July to 22 September and from 25 September to 1 November. Expected values based on proportion of minimum number alive in each class during those periods

	Class	Observed	Expected	χ^2	df	Significance
Group 1	Males	8	11	1.82	1	.30<P<.50
	Females	12	9			
	Juveniles	4	3			
	Subadults	4	5	0.28	2	P>.90
	Adults	12	12			
Group 2	Males	7	10	1.80	1	.30<P<.50
	Females	13	10			
	Juveniles	5	3			
	Subadults	9	9	1.25	3	.70<P<.80
	Adults	6	8			

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